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Environmental and anthropogenic factors affecting the respiratory toxicity of volcanic ash in vitro

Ines Tomašek (1,2), Claire J. Horwell (1), David E. Damby (3), Paul M. Ayris (3), Hana Barošová (2), Christoph Geers (2), Alke Petri-Fink (2), Barbara Rothen-Rutishauser (2), Martin J.D. Clift (2,4)

(1) Institute of Hazard, Risk and Resilience, Department of Earth Sciences, Durham University, Durham, United Kingdom, (2) BioNanomaterials, Adolphe Merkle Institute, University of Fribourg, Fribourg, Switzerland, (3) Department of Earth and Environmental Sciences, Section for Mineralogy, Petrology and Geochemistry, Ludwig-Maximilians-Universität München, Munich, Germany, (4) Institute of Life Sciences, Swansea University Medical School, Swansea, United Kingdom

Human exposure to inhalable volcanic ash particles following an eruption is a health concern, as respirable-sized particles can potentially contribute towards adverse respiratory health effects, such as the onset or exacerbation of respiratory and cardiovascular diseases. Although there is substantial information on the mineralogical properties of volcanic ash that may influence its biological reactivity, knowledge as to how external factors, such as air pollution, contribute to and augment the potential reactivity is limited. To determine the respiratory effects of volcanic particle interactions with anthropogenic pollution and volcanic gases we will experimentally assess: (i) physicochemical characteristics of volcanic ash relevant to respiratory toxicity; (ii) the effects of simultaneously inhaling anthropogenic pollution (i.e. diesel exhaust particles (DEP)) and volcanic ash (of different origins); (iii) alteration of volcanic ash toxicity following interaction with volcanic gases.

In order to gain a first understanding of the biological impact of the respirable fraction of volcanic ash when inhaled with DEP in vitro, we used a sophisticated 3D triple cell co-culture model of the human alveolar epithelial tissue barrier. The multi-cellular system was exposed to DEP [0.02 mg/mL] and then exposed to either a single or repeated dose of well-characterised respirable volcanic ash (0.26 ± 0.09 or 0.89 ± 0.29 μg/cm2, respectively) from the Soufrière Hills volcano, Montserrat for a period of 24 hours using a pseudo-air liquid interface approach. Cultures were subsequently assessed for adverse biological endpoints including cytotoxicity, oxidative stress and (pro)-inflammatory responses. Results indicated that the combination of DEP and respirable volcanic ash at sub-lethal concentrations incited a significant release of pro-inflammatory markers that was greater than the response for either DEP or volcanic ash, independently.

Further work is planned, to determine if this effect is maintained for ash exposure concurrent with complete vehicle exhaust, containing both particulate and gaseous components, as well as with samples exposed to an experimentally-simulated volcanic plume environment. It is envisaged that the findings of this study will provide a better understanding of the potential risk posed by combined exposure to urban pollution and volcanic ash towards human health.